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(54) **SYSTEM OF CONTROLLING COOLING SYSTEM FOR ELECTRONIC DEVICES.**

(57) In a system for cooling electronic devices wherein devices to be cooled are air-cooled by a plurality of cooling fans, and the number of revolutions of the cooling fans is controlled depending upon the temperature of the devices to be cooled or depending upon the temperature of the intaken air or the exhausted air, the improvement wherein; in case some of the cooling fans become defective, other cooling fans are liberated from the condition in which their number of revolutions is controlled and are run at full speeds, so that operation of the electronic devices can be continued maintaining high reliability upon a simply constructed circuit.

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# DESCRIPTION

## COOLING METHOD CONTROL SYSTEM FOR ELECTRONIC APPARATUS

### TECHNICAL FIELD

The present invention relates to a cooling system which cools interior of an electronic apparatus such as an information processing apparatus, etc. with a plurality of cooling fans, and particularly to improvment in the control system for cooling system which controls a number of rotations of cooling fan in accordance with the heat generated of the electronic apparatus.

### BACKGROUND ART

Heats generated within an electronic apparatus gives very considerable influence on parts of electronic circuits and particularly it results in, as is well known, notonly deterioration of performance but also breakdown of semiconductor elements in a semiconductor integrated circuit comprising semiconductor elements which determine the performance of electronic apparatus.

In general, a method for exhausting the heat generated to the outside of apparatus with a cooling fan or an external air is supplied into the apparatus for cooling the inside of apparatus is employed.

However, if temperature condition within the apparatus depends on normal rotation of such cooling fan, if the

cooling fan fails and stops its rotation, internal temperature of apparatus certainly rises quickly and may result in breakdown of semiconductor elements, etc.

Accordingly, a plurality of cooling fans are usually provided in order to prevent quick temperature rise within the apparatus due to generation of such failure of cooling fan and the apparatus is caused to stop the operation by turning OFF the power supply of apparatus before the interior reaches risky temperature.

If power supply of apparatus during the operation is turned OFF, a considerable time is lost until restart of operation from resetting of power switch.

Therefore, it is desired that the electronic apparatus cooling system is proposed, which can avoid intermission in supply of electrical power as much as possible for failure of cooling fan and is capable of keeping safety of apparatus.

Fig. 1 is an example of a cooling system control circuit of typical electronic apparatus of the prior art.

In the apparatus 1 as an object of cooling, heat generated within the apparatus is exhausted by a plurality of cooling fans 2. Each cooling fan 2 is provided, for example, with a wind sensor 3 which senses flow of air or ventilation and it is connected to a failure detection circuit 4.

It is an example of the structure of a wind sensor 3 that a pair of heater and a heat sensible element are used,

for example. When the fan normally rotates assuring ventilation, heat generated from the heater is always exhausted but if ventilation is lowered, heat generated from the heater is accummulated and a signal issued from the heat sensible element changes.

If the cooling fan 2 has lost the capability of ventilation, for example, due to over heat burning of fan motor or entry of foreign matter into the rotatable portion or if the ventilation capability is lowered, the failure detection circuit 4 detects failure of cooling fan from level change of signal sent from the wind sensor 3.

The failure detection circuit 4 displays the warning for failure of cooling fan at the monitor board 5 and meanwhile sends power supply OFF signal to the power supply control circuit 7 after a present period through a delay circuit 6.

Within this setting period, data required for stop of operation is saved and the power supply of apparatus is turned OFF with the power OFF signal, disabling the function of apparatus. Moreover, the apparatus does not generate heat and thereby it is protected from trouble.

As described above, if the cooling fan stops due to a failure, the apparatus is protected from a trouble but it is a large demerit for operation of apparatus that it is inevitably caused to stop operation. However, an accidental stop of a cooling fan, for example, among a plurality of cooling fans is an assumable failure to be generated for the

electronic apparatus which is rendered to operate continuously for a long period.

Since temperature within the apparatus is naturally influenced by external temperature, a number of cooling fans must be detemined considering not only stop of operation by failure but also environmental temperature of apparatus. The cooling fans are operated usually with an excessive ventilation capability estimating sufficient safe operation.

If an external temperature is sufficiently low, ventilation is carried out uselessly, generating problems of power consumption, curtailment of operation life of motor bearing and noise, etc.

Here, an idea that a number of rotations of cooling fan is controlled to minimum value in accordance with detected load condition or temperature of electronic apparatus is also proposed (for example, Laid-open Patent No. 58-186998, 59-55099, etc.), if either one of plural cooling fans fails, the same processings are required and therefore operations of apparatus must be stopped.

## DISCLOSURE OF INVENTION

It is an object of the present invention to dissolve the problems described above. In order to attain this object, the present invention discloses a cooling method control system for electronic apparatus wherein a number of rotations of cooling fans is lowered to continue the ventilation with the minimum ventilation capability under

the ordinary operation with control of a number of rotations of cooling fans, or all cooling fans except for a defective cooling fan are caused to rotate at full speed if the specified number of cooling fans, for example, only one cooling fan fails, or the power supply of the apparatus as a whole is turned OFF if the cooling fans over the specified number, for example, two or more cooling fans fail.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram illustrating a prior art. Fig. 2 is a block diagram illustrating an embodiment of the present invention. Fig. 3 is a circuit diagram illustrating details of a part of Fig. 2.

BEST MODE OF CARRYING OUT THE INVENTION

Fig. 2 is a block diagram of an embodiment of the present invention. The like elements are given the like reference symbols throughout the drawings.

Under the normal operating condition, a temperature sensor 10 provided to the external air inlet side of apparatus converts an external air temperature through a temperature monitor circuit 11 and sends a signal to a rotation control circuit 12.

The temperature signal controls a number of rotations of cooling fans 2 and carries out adequate ventilation for the apparatus.

As a temperature sensor 10, a known sensor,for example,

a thermistor may be used. The temperature sensor 10 may be provided in the exhausting side or within the apparatus, in place of the air inlet side as shown in the drawing. In this embodiment, the temperature sensor 10 is provided in the air inlet side because a concept of controlling a number of rotations of cooling fans 2 depending on the environmental temperature is employed. This system is sufficient when heat generated by apparatus 1 is constant. In case the temperature sensor is provided to the air exhausting side, it is impossible to accurately know the temperature condition of the apparatus as a whole, but when it is provided in the air inlet side, such problem can be dissolved.

If a failure occurs, a failure detection circuit 4 detects that the cooling fans 2 stop the operations, a failure discrimination circuit 41 discriminates a number of defective cooling fans whether it is a specified number of fans, namely it is only one or exceeding the specified numbers.

When a number of defective cooling fans is within the specified number, the failure detection circuit 5 displays the warning for defective cooling fans on the monitor board 5.

Simultaneously, the rotation control circuit 12 turns OFF the power supply of defective cooling fan, controls a number of rotations of other normal cooling fans to the full speed operation in order to keep the necessary ventilation capability by compensating for the ventilation capability of

defective fans.

Thereby, operations of electronic apparatus can be continued.

In this case, it is also allowed that the operations may be suspended if the temperature of air is sensed to be higher than the specified value by the temperature sensor 10 and sufficient ventilation cannot be expected even with full speed operations of the normally operating cooling fans.

Meanwhile, when the failure discriminating circuit 41 discriminates that a failure occurs in the fans exceeding the specified numbers, for example, the power OFF signal is sent to the power supply control circuit 7 through a delay circuit 6. After a certain period, the power supply for the apparatus as a whole is turned OFF and thereby the apparatus stops the operations.

Fig. 3 is a detail circuit diagram of the failure discrimination circuit 41 and temperature monitor circuit 11. The same reference symbols as those in Fig. 2 mean the same elements. L1 L3 are failure signal leads corresponding to the signals sent from the wind sensor 3 of each cooling fan 2. Combined two leads of them are connected to the input of AND gates 411 413, the output of them are connected to the input of OR gate 414. Thereby, it can be detected that two or more cooling fans 2 are defective and the stop processing is carried out through the delay circuit 6. L1 L3 are also connected to the input of the OR gate 415 and thereby it can be detected that at least one cool-

ing fan has failed. When such signal and the signal obtained by inverting an output of the OR gate 414 with an invertor 417 are input to the AND gate 416, an output therefrom indicates that only one cooling fan 2 is defective and it is input to the rotation control circuit 12. If a cooling fan uses a DC motor, the rotation control circuit 12 includes only a variable voltage generator 121 and the cooling fan 2 uses an AC motor, it includes a circuit for frequency control or conduction phase angle control. These are already known. In any case, if a signal is received from the failure discrimination circuit 41, the maximum rated power is applied to the cooling fans 2 in order to operate them at the full speed. For example, an input power is directly bypassed with a relay 122, etc.

An output of voltage generator 121 is distributed to respective cooling fans through the switches 123 125 which can be independently turned ON and OFF and the switch of defective cooling fan is turned OFF by the signals L1 L3.

The temperature monitor circuit 11 comprises a receiving circuit 111 which receives a signal sent from the temperature sensor 10 and outputs a signal (for example, a voltage signal) proportional to temperature and a comparator 112 which compares an output of said 111 with the reference value (REF) and detects that the temperature of sucked air is higher than the specified value. An output of the comparator 112 is sent to the failure detection circuit 4 and is also input to the OR gate 414 of the failure discri-

mination circuit 41, for start of quick stop processing.

In above description, a printed wiring board is estimated as the apparatus 1 to be cooled, but a system for cooling by air the cooling water to be used for cooling such printed wiring board is also employed recently.

The present invention can be adopted, of course, to a air-cooling system for the cooling water to be used for such system.

In this case, a number of rotations of cooling fans may be controlled by measuring water temperature itself in place of measuring sucked air temperature with the temperature sensor 10.

When any one cooling fan stops and the air migrates to the adjacent fans through such defective fan, cooling efficiency is lowered. It is desired to provide a duct for each fan or separation plates between respective fans in order to prevent deterioration of cooling efficiency.

As explained above, in the air cooling system which controls a number of rotations of a plurality of cooling fans in the present invention, hily reliable colling can be maintained only with a simplified circuit by restoring a control for a number of rotations of remainaing cooling fans and causing them to rotate at a full speed if a part of cooling fans fails.

When a number of rotations of air cooling fan is controlled in accordance with temperature of apparatus, if a part of fans fails, temperature rises and the control is so

carried out that a number of rotations of fans must be increased in order to compensate for temperature rise, even if the number of rotations of remaining fans is not raised as in the case of the present invention.

However, the sensors must be provided to many points of the apparatus in order to accurately measure the temperature of the apparatus itself, because if only one sensor is provided, any problem does not occur when the fan near to the sensor happens to fail but when other fan fails, temperature rise at the area near such fan cannot be measured accurately.

Regarding this point, in case temperature of sucked air is mesusred as in the case of the embodiment of the present application, fluctuation of temperature resulting from measuring position can be neglected even when any fan fails and therefore only one sensor is sufficient and cost can also be lowered.

Moreover, if a part of cooling fans fails, distribution of air flow within the apparatus and therefore it is dangerous to directly and continuously adopt the logic for controlling a number of rotations on the basis of the precoditions for normal operations of all fans. It is also possible to design the cooling system including the case where the logic of rotation control is adopted to failure of a part of cooling fans. But, the circuit is complicated in this case, resulting in rise of cost.

Therefore, it is preferential in cost and reliability

that temperature of sucked air is measured, control for a number of rotations are restored when a part of cooling fans fails and the remaining fans are controlled to rotate at the full speed.

INDUSTRIAL APPLICABILITY

The present invention provides a distinctive effect to the air cooling system for the apparatus such as electronic computer which is required to have high packing density and high reliability or to the air cooling system for the apparatus for cooling such apparatus with water.

## CLAIMS

(1) Cooling method control system for electronic apparatus comprising a plurality of cooling fans which cools by air an object to be cooled, a temperature monitor circuit which detects temperature of air sucked or to be exhausted, and a rotation control circuit which cntrols a number of rotations of said air cooling fans in accordance with an output of said temperature monitor circuit, wherein further comprising a sensor which senses failure of said respective cooling fans, a failure discriminating circuit which detects that the cooling fans under the specified number are defective from an output of said sensor, and a means which restores control of rotation control circuit by an output of said temperature monitor circuit with an output of said failure discrimination circuit and rotates the cooling fans other than said defective fans at the full speed.

(2) Cooling method control system for electronic apparatus as defined in claimn (1), wherein said temperature monitor circuit measures temperature of air sucked and is provided with a comparator which detects that said temperature of sucked air is higher than the specified value.

(3) Cooling method control system for electronic apparatus as defined in claim (1) or (2), wherein operations of electronic apparatus is suspended according to the predetermined procedures without restoring rotation control in

such a case that a number of defective fans excceeds the specified number or temperature of air sucked is higher than the specified temperature.

Fig. 1

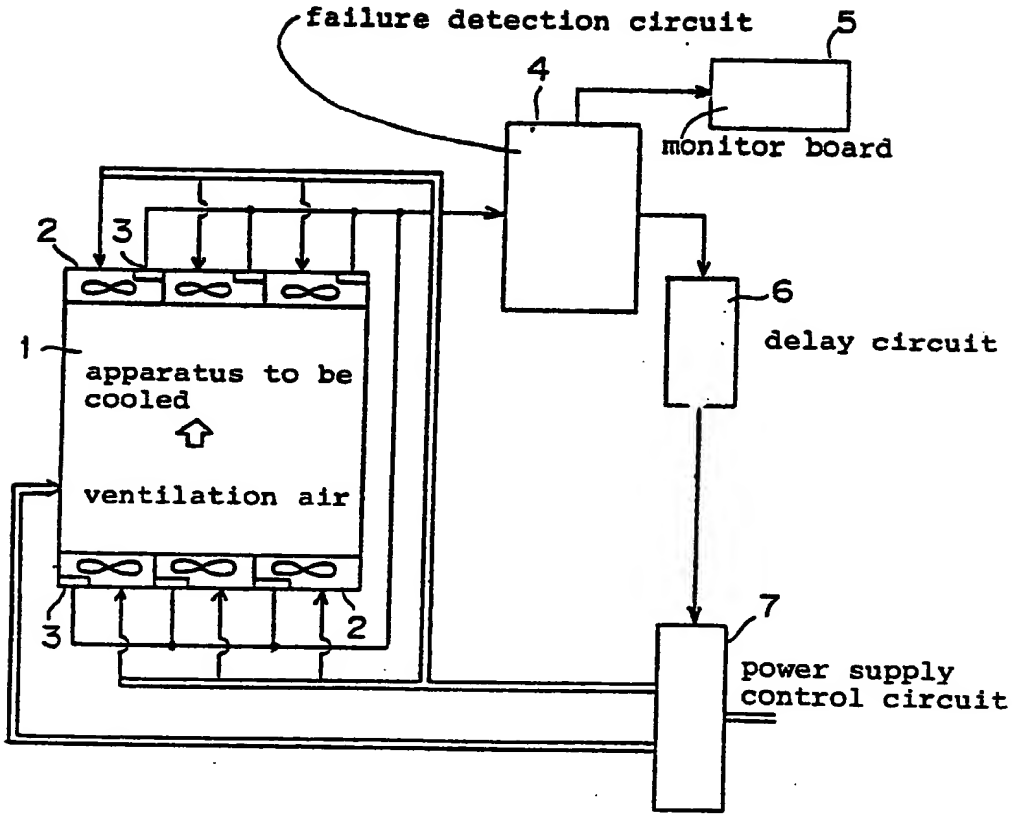

failure detection circuit
5
4
monitor board
2
3
6
delay circuit
1
apparatus to be cooled
ventilation air
3
2
7
power supply control circuit

Fig. 2

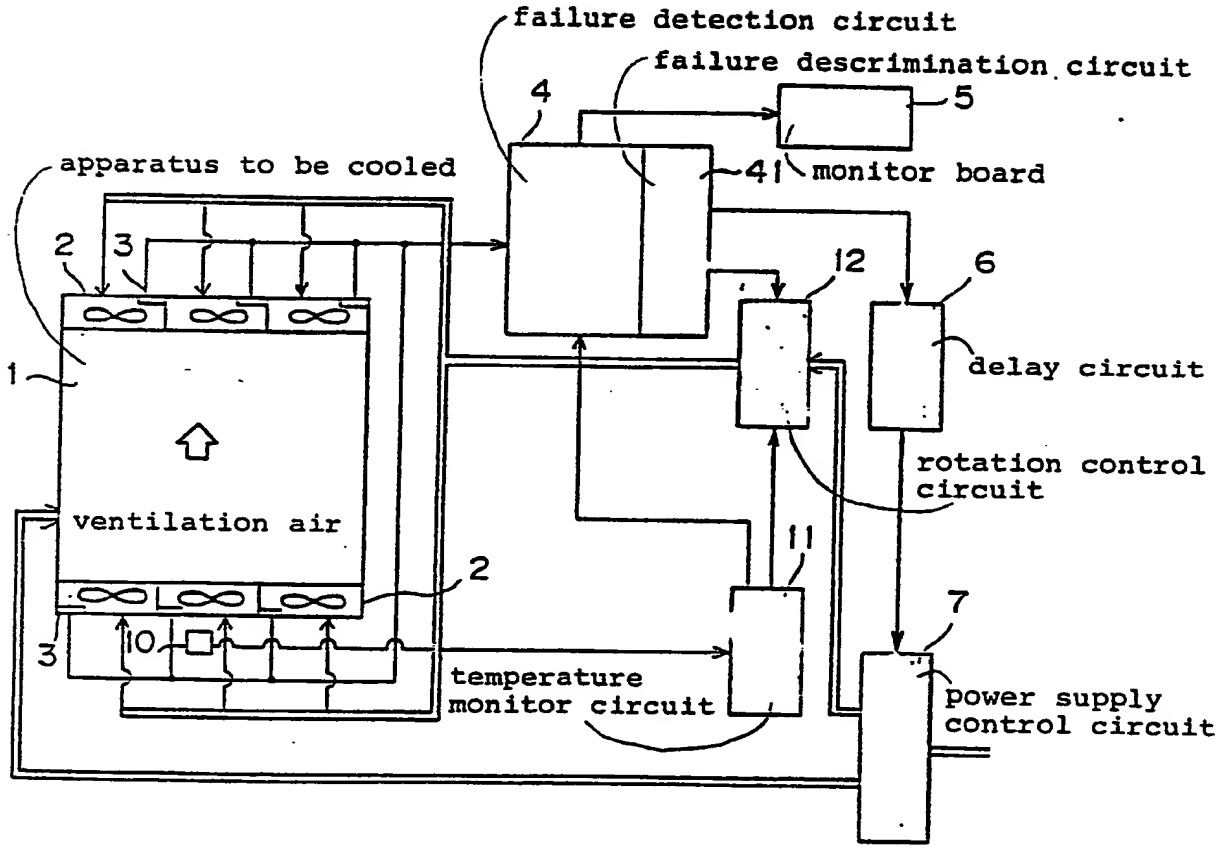
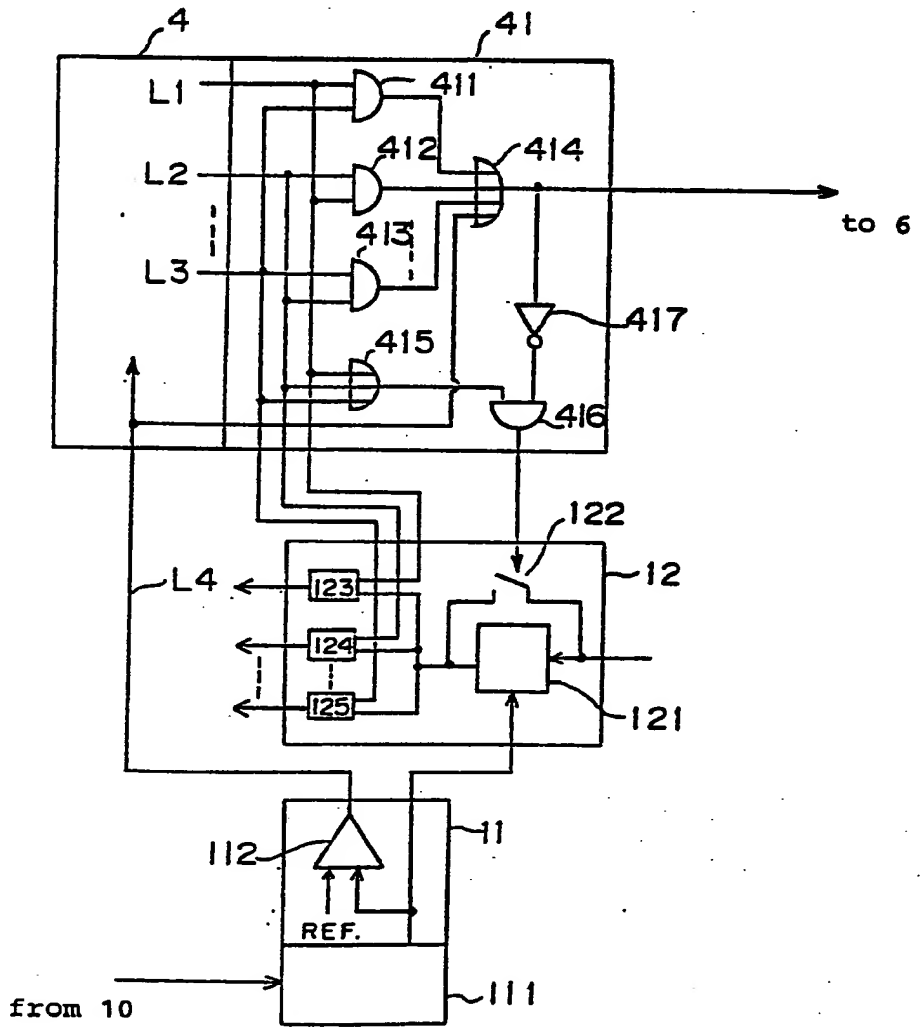

failure detection circuit
failure descrimination circuit
4
5
apparatus to be cooled
41
monitor board
2
3
12
6
delay circuit
1
rotation control circuit
ventilation air
11
2
7
3
10
temperature monitor circuit
power supply control circuit

Fig. 3


4
41
L1
411
412
414
L2
to 6
413
L3
417
415
416
122
L4
123
12
124
125
121
112
11
REF.
111
from 10

# INTERNATIONAL SEARCH REPORT

0214297

International Application No PCT/JP86/00058

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl[4] G06F1/00

II. FIELDS SEARCHED

Minimum Documentation Searched [5]

| Classification System | Classification Symbols |
|---|---|
| IPC | G06F1/00 |

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [6]

Jitsuyo Shinan Koho 1970 - 1986
Kokai Jitsuyo Shinan Koho 1971 - 1986

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

| Category* | Citation of Document [16] with indication where appropriate of the relevant passages [17] | Relevant to Claim No [18] |
|---|---|---|
| Y | JP, A, 57-64830 (Meidensha Electric Mfg. Co., Ltd.) 20 April 1982 (20. 04. 82) Column 6, lines 10 to 15 (Family: none) | 1-3 |
| Y | "Hatsumei Kyokai Kokai Giho" 80-1057, Vol 5-7 21 April 1980 (21. 04. 80) | 1-3 |

* Special categories of cited documents. [15]

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"P" document published prior to the international filing date but later than the priority date claimed

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

IV. CERTIFICATION

| Date of the Actual Completion of the International Search [2] | Date of Mailing of this International Search Report [9] |
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| International Searching Authority [1] | Signature of Authorized Officer [20] |
| Japanese Patent Office | |

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